High Performance Enclosure Details

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Learning Objectives

- *Apply concepts of separating interior and exterior environments to increase enclosure functionality*
- *Choose from various design approaches to create a high performance*
- *Identify design parameters and situations that have been successfully addressed in examples presented*
- *Recommend to clients the advantages and techniques available in designing high-performance enclosures*

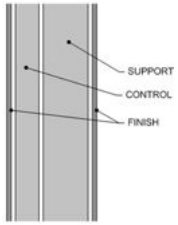
The Devil is in the Details

- Targets and codes have raised awareness
- People “know” you need
  - Lots of insulation value
  - No thermal bridges
  - No air leaks
  - A drainage plane leading to flashing
- But, how to this?

Basic Functions of the Enclosure

- 1. Support
  - Resist and transfer physical forces from inside and out
- 2. Control
  - Control mass and energy flows
- 3. Finish
  - Interior and exterior surfaces for people
- Distribution – a building function

Functional Layers



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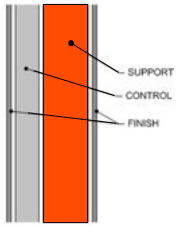
Basic Enclosure Functions

- **Support**
  - **Resist & transfer physical forces from inside and out**
    - Lateral (wind, earthquake)
    - Gravity (snow, dead, use)
    - Rheological (shrink, swell)
    - Impact, wear, abrasion
- Control
  - Control mass and energy flows
- Finish
  - Interior and exterior surfaces for people

Functional Layers



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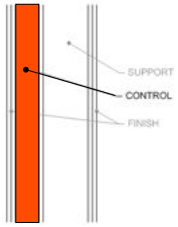
Enclosures No. 6 /

Basic Enclosure Functions

- Support
  - Resist & transfer physical forces from inside and out
- **Control**
  - **Control mass and energy flows**
    - **Rain** (and soil moisture)
      - Drainage plane, capillary break, etc.
    - **Air**
      - Continuous air barrier
    - **Heat**
      - Continuous layer of insulation
    - **Vapor**
      - Balance of wetting/drying
- Finish
  - Interior and exterior surfaces for people

Functional Layers



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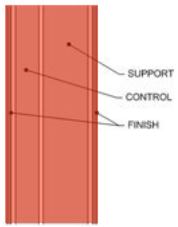
Enclosures No. 7 /

Other Control . . .

- Support
- **Control**
  - **Fire**
    - **Penetration**
    - **Propagation**
  - **Sound**
    - **Penetration**
    - **Reflection**
  - **Light**
    - **Diffuse/glare**
    - **View**
- Finish

Functional Layers



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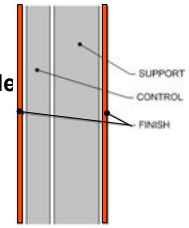
Enclosures No. 8 /

Basic Enclosure Functions

- Support
  - Resist & transfer physical forces from inside and out
- Control
  - Control mass and energy flows
- **Finish**
  - **Interior & exterior surfaces for people**
    - Color, speculance
    - Pattern, texture

Functional Layers



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History of Control Functions

- Older Buildings
  - One layer does everything
- Newer Building
  - Separate layers,
    . . . separate functions

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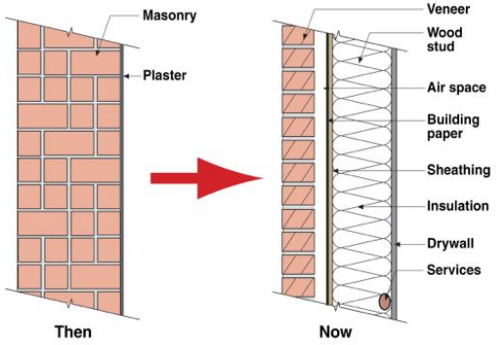
No. 10

Changes



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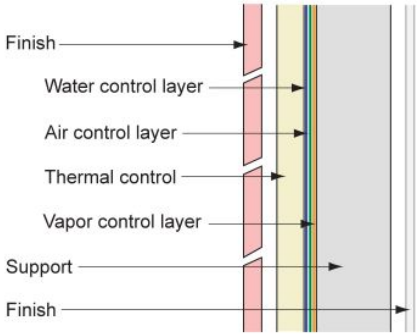
The "Perfect Wall"

- Finish of whatever
  - May need ventilated
- **Control continuity is the key**
  - Water: Drainage gap + drainage plane
  - Air: Air barrier
  - Heat: Insulation
  - Vapor: vapor barrier



What is a High-performance enclosure?

- One which provides high levels of control
- Poor *continuity* limits performance
- Poor continuity causes most problems too:
  - E.g. air leakage condensation
  - Rain leakage
  - Surface condensation
  - Cold windows
- This presentation: continuity + high levels

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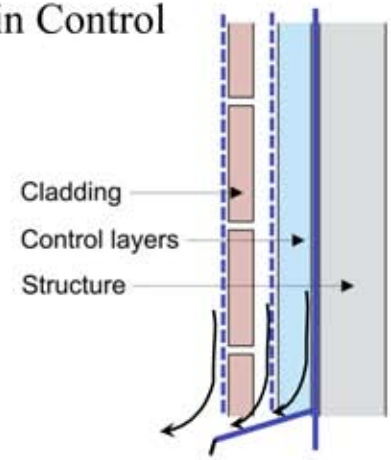
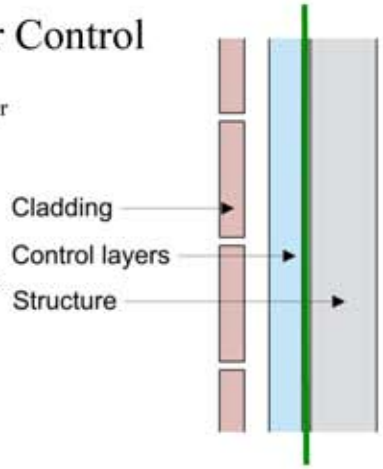
Rain Control

- Rain shedding
- Drainage
- Must integrate with flashing, drainholes
- Overlap everything
- No holes



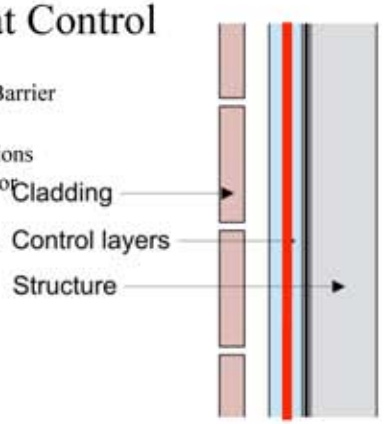
Air Control

- Continuous Air Barrier
  - Continuous
  - Stiff
  - Strong
  - Durable
  - Air Impermeable
- Only very small holes tolerable



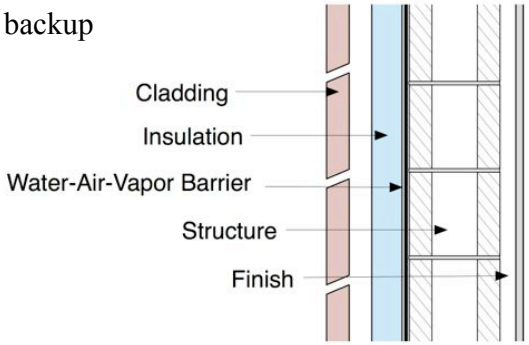
Heat Control

- Continuous Thermal Barrier
  - Even R10 is good
- Accept small penetrations as long as no comfort or durability issues
- Windows are a major concern
  - Heat loss/gain
  - Solar gain



Perfect Wall

- CMU backup



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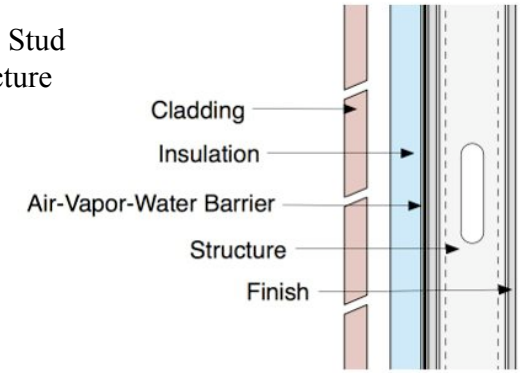
Perfect Wall

- Steel Stud Structure



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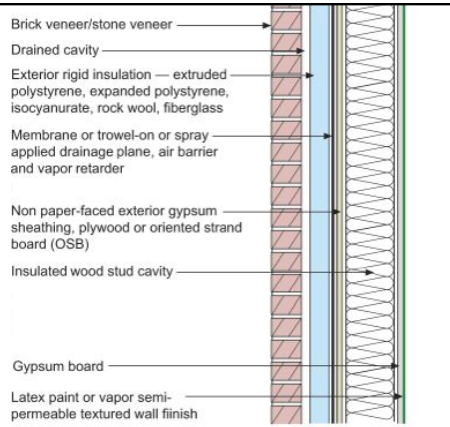

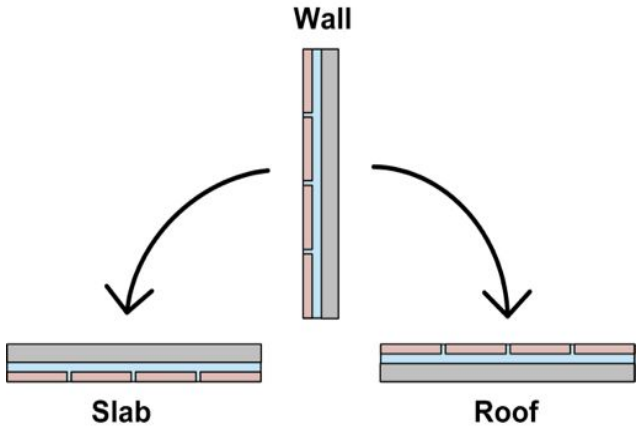

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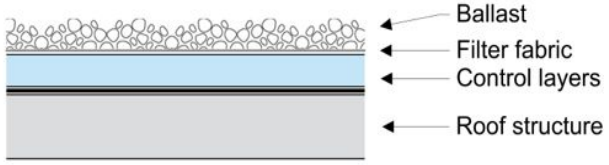

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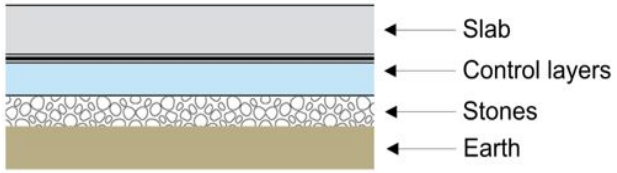

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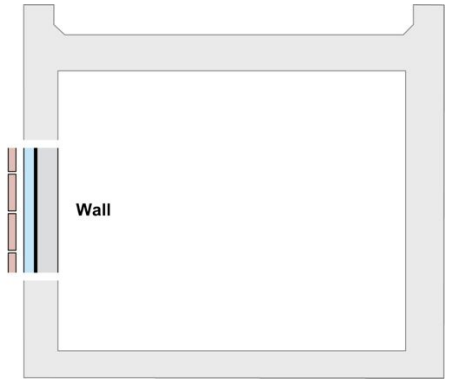

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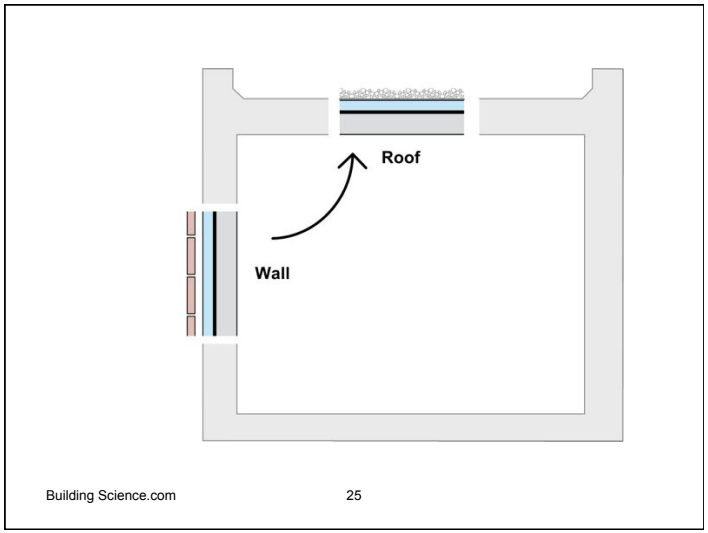
Roof
Wall
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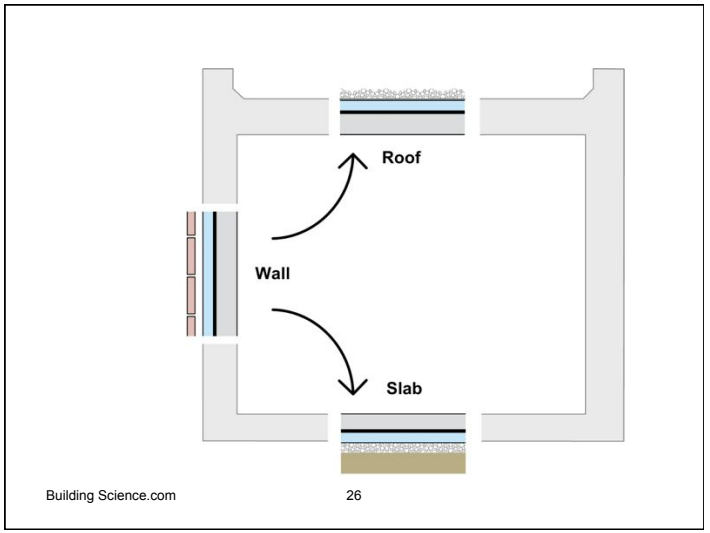
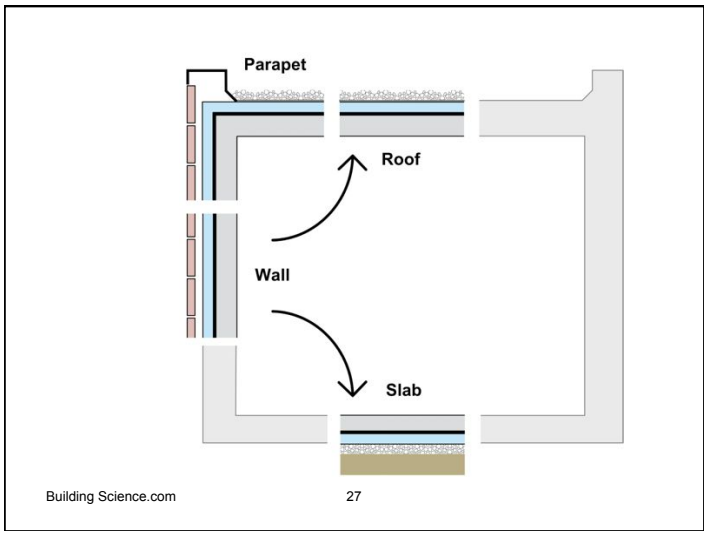
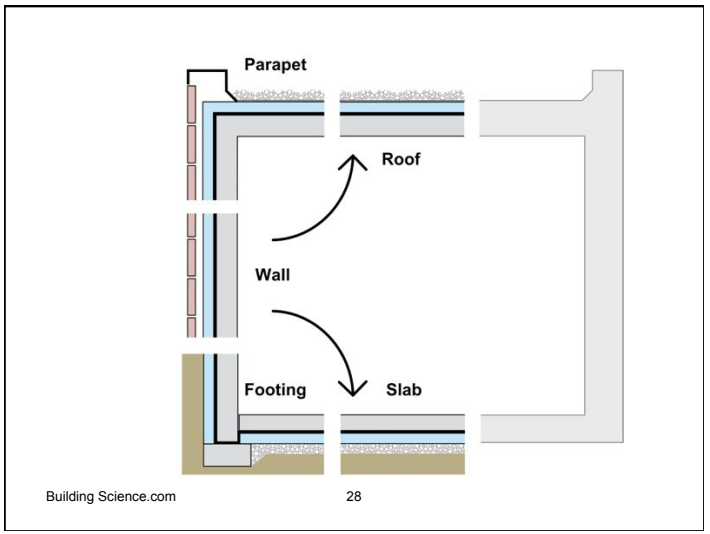
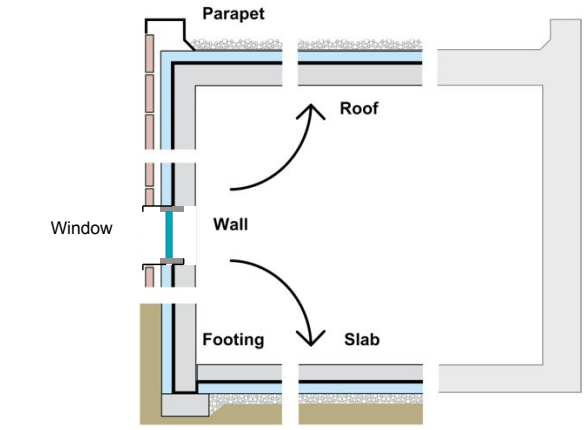
25


Roof
Wall
Slab
Building Science.com
26


Parapet
Roof
Wall
Slab
Building Science.com
27


Parapet
Roof
Wall
Footing
Slab
Building Science.com
28



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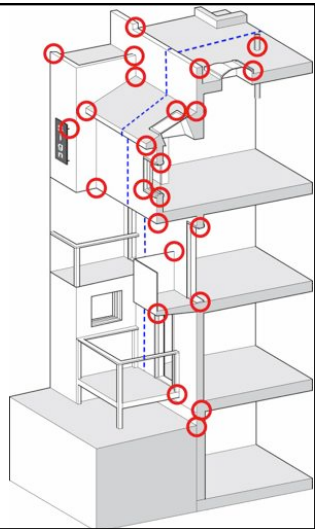
Enclosure Design: Details

- Details demand the same approach as the enclosure.
- Scaled drawings required at ◯

Details needed at:

- Change in *plane*
- Change in *material*
- Change in *trade*



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Details

- Need to trace continuity of
  - Structure (connections)
  - Water control
  - Air Control
  - Thermal control

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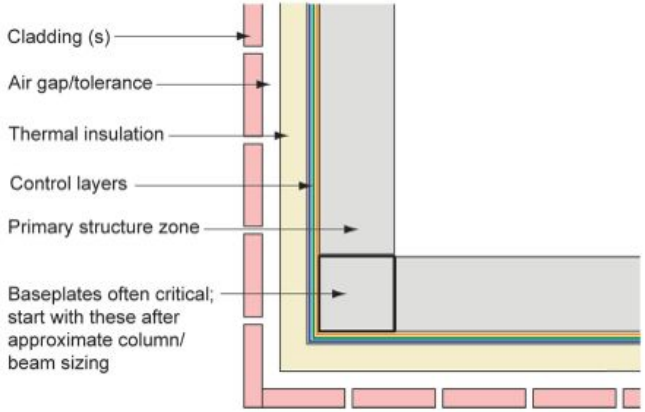
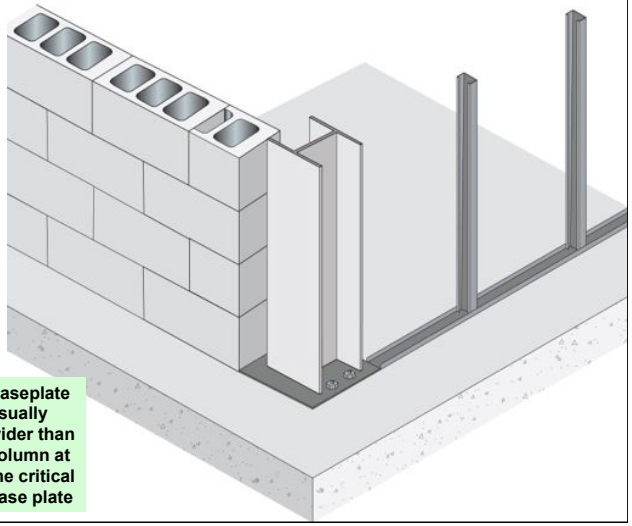
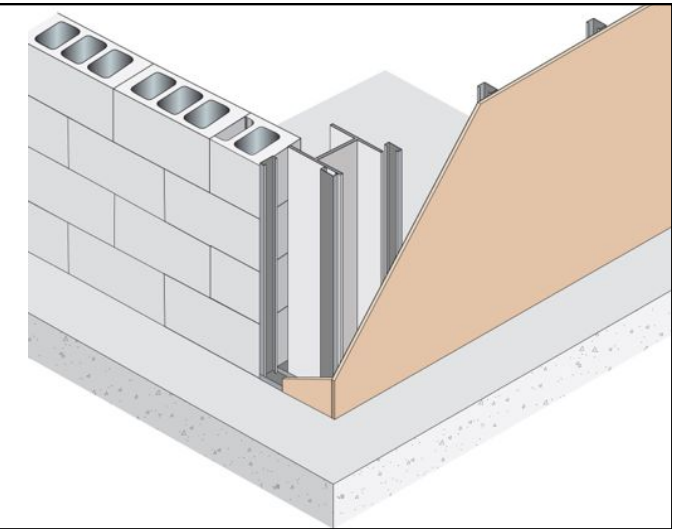
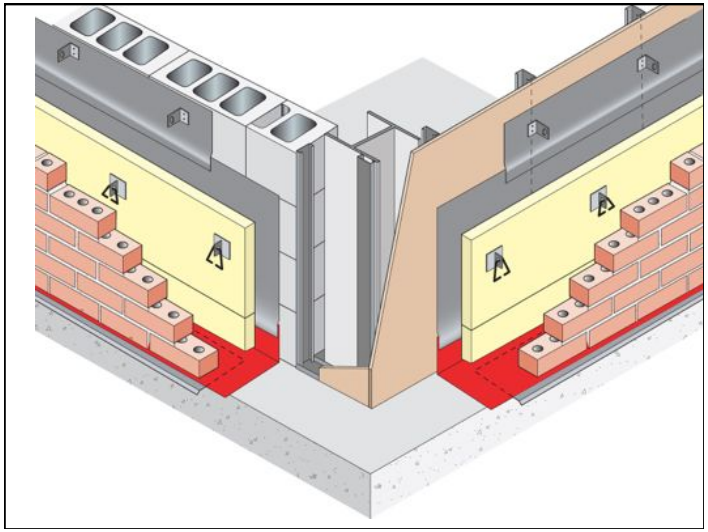
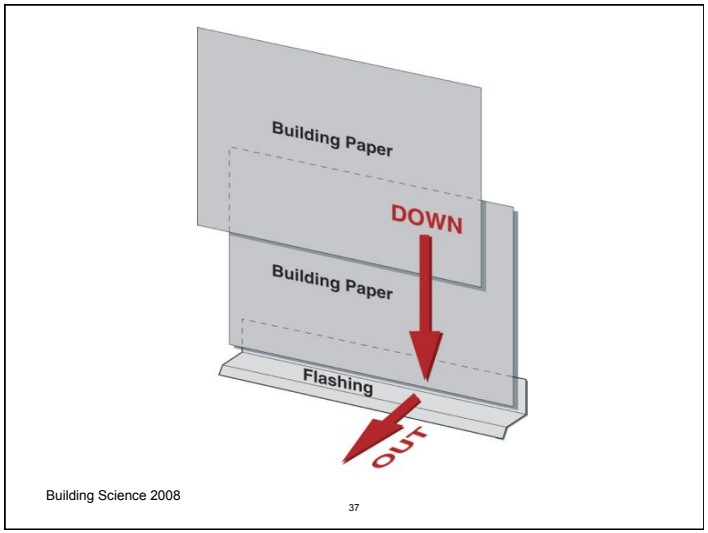
Commercial:Early stage planning










Building Paper
DOWN
Building Paper
Flashing
OUT
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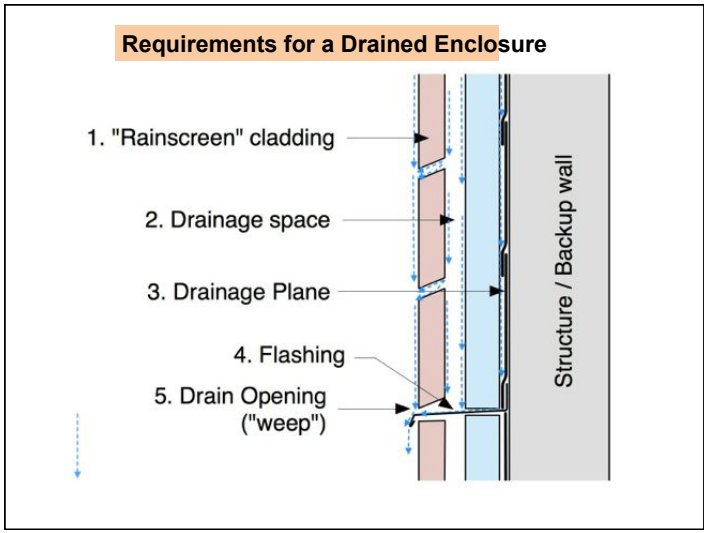
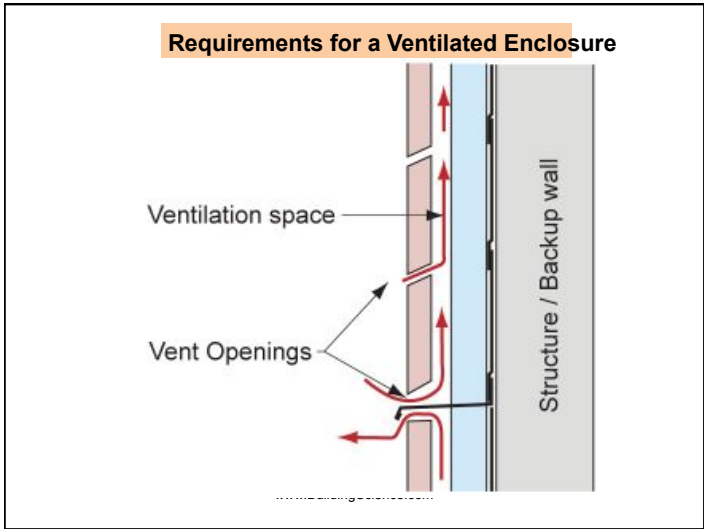
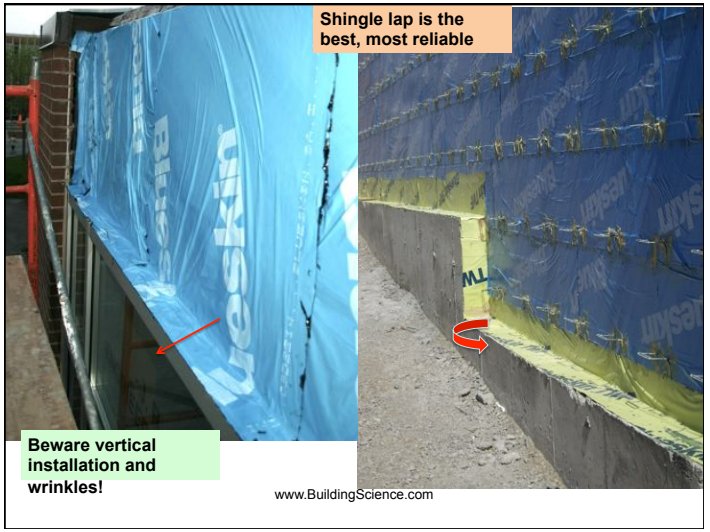

Requirements for a Drained Enclosure
1. "Rainscreen" cladding
2. Drainage space
3. Drainage Plane
4. Flashing
5. Drain Opening ("weep")
Structure / Backup wall


Requirements for a Ventilated Enclosure
Ventilation space
Vent Openings
Structure / Backup wall


Shingle lap is the best, most reliable
Beware vertical installation and wrinkles!
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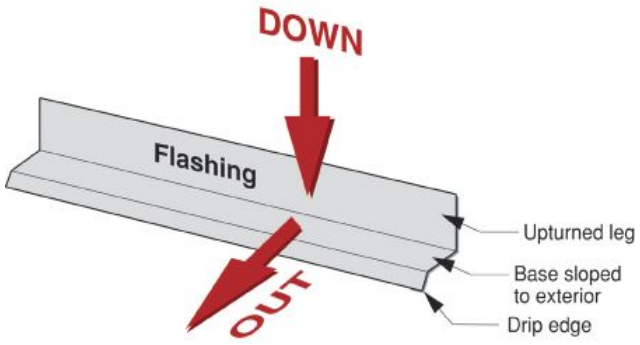
Flashing must be waterproof



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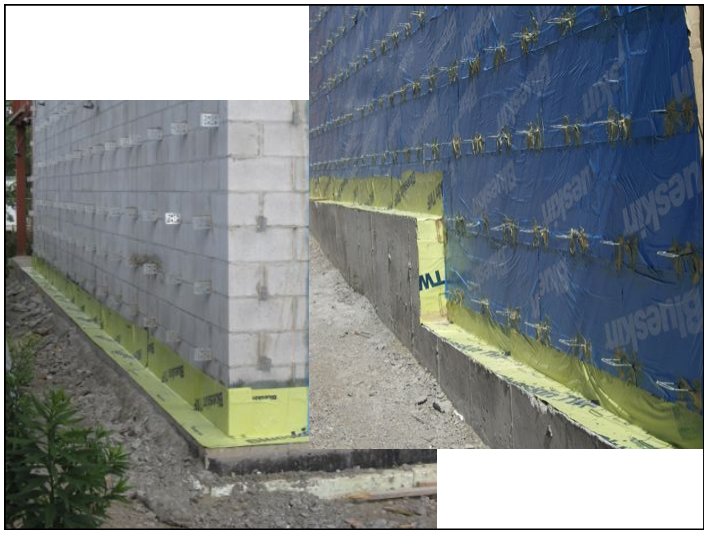
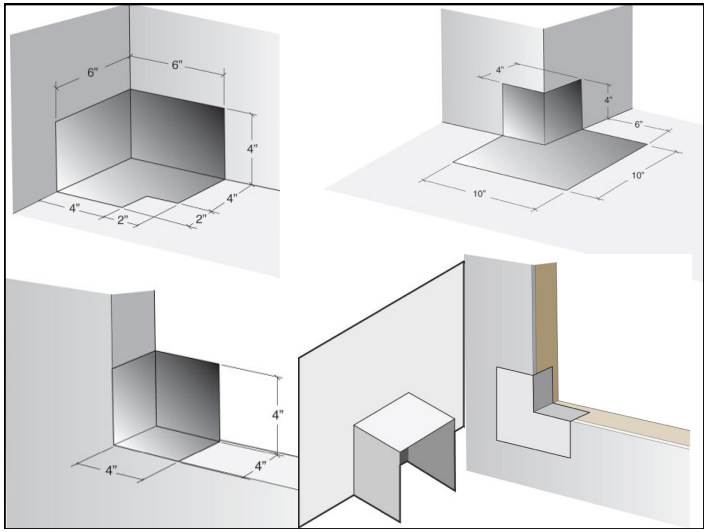
Joseph Lstiburek – Rain Control 41





Windows

- Finding the air-water-thermal layer can be challenging
- Usually, best air and water seal is inner edge
  - few chances for water leaks at corners
- Alu windows have thermal line at TB
  - Line up with thermal control in wall

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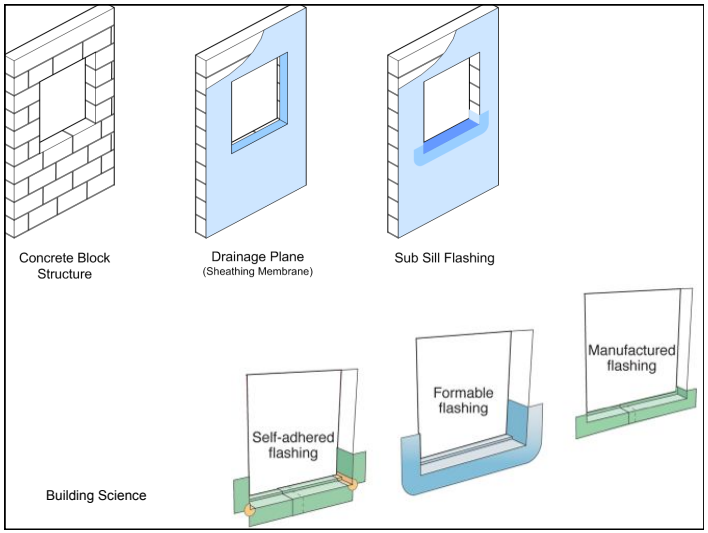
Leaky windows

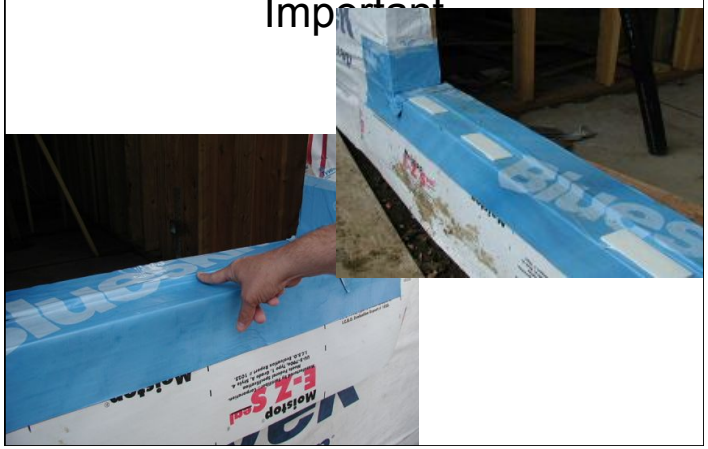
- Studs and sheathing are sensitive to leaks

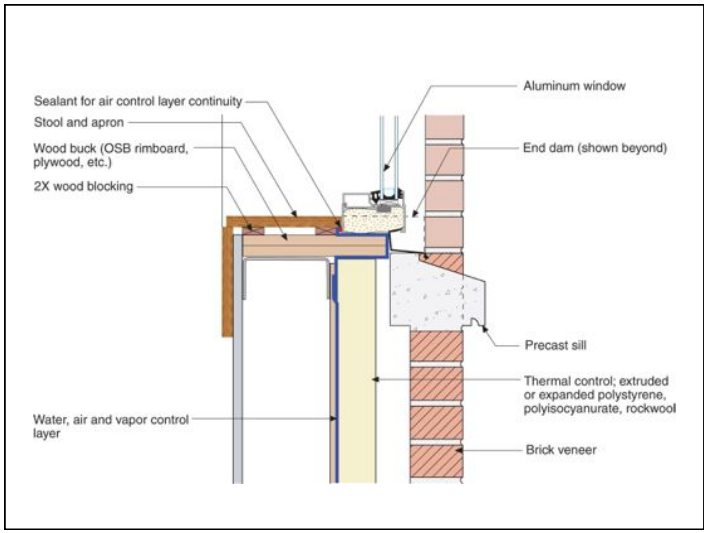


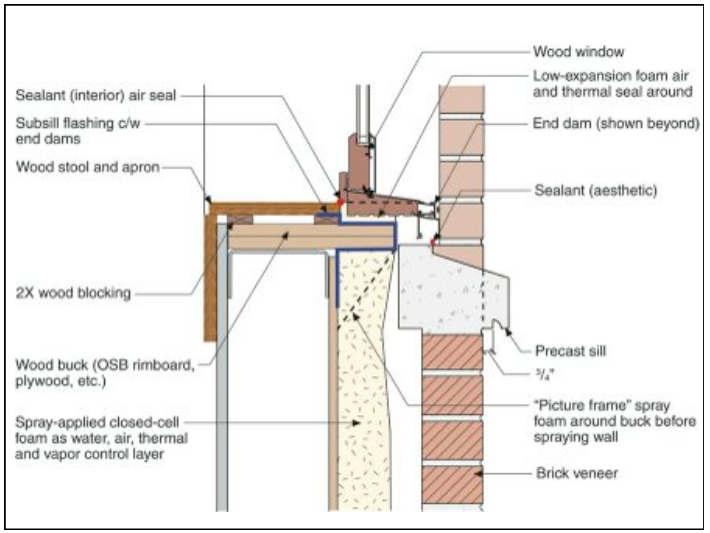
Mixed membrane + liquid

Often use membranes for transitions

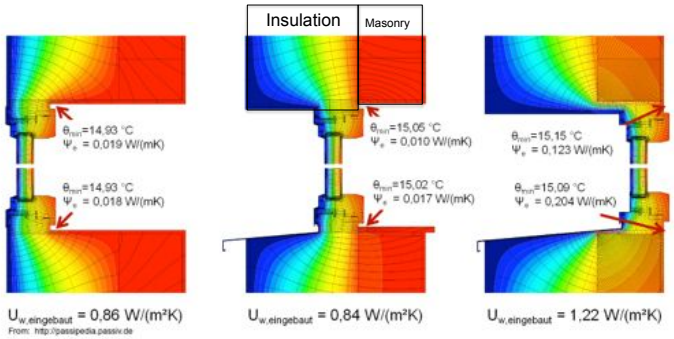
Backdams / Slopes are Important




Sealant for air control layer continuity
Stool and apron
Wood buck (OSB rimboard, plywood, etc.)
2X wood blocking
Water, air and vapor control layer
Aluminum window
End dam (shown beyond)
Precast sill
Thermal control; extruded or expanded polystyrene, polyisocyanurate, rockwool
Brick veneer


Sealant (interior) air seal
Subsill flashing c/w end dams
Wood stool and apron
2X wood blocking
Wood buck (OSB rimboard, plywood, etc.)
Spray-applied closed-cell foam as water, air, thermal and vapor control layer
Wood window
Low-expansion foam air and thermal seal around
End dam (shown beyond)
Sealant (aesthetic)
Precast sill
¾"
"Picture frame" spray foam around buck before spraying wall
Brick veneer

Window Location



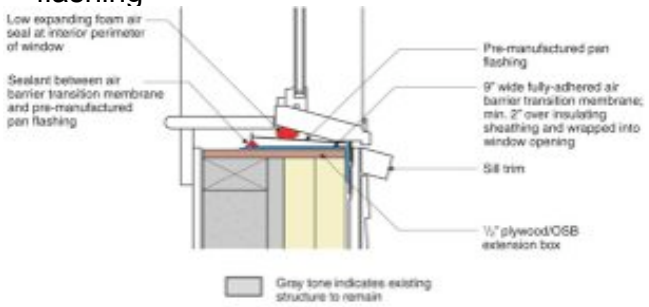
Outie Window
(but within thermal line)

Innie Window
(but within thermal line)

Innie Window
(inside of thermal line)

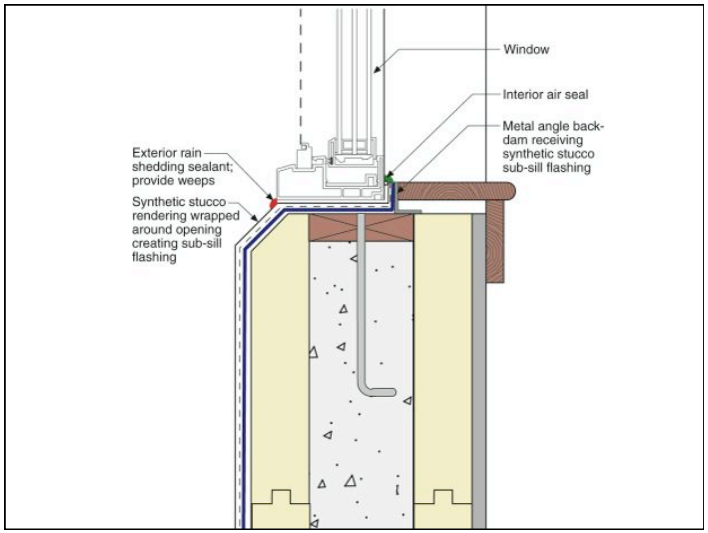
- Beware strap anchor air leakage

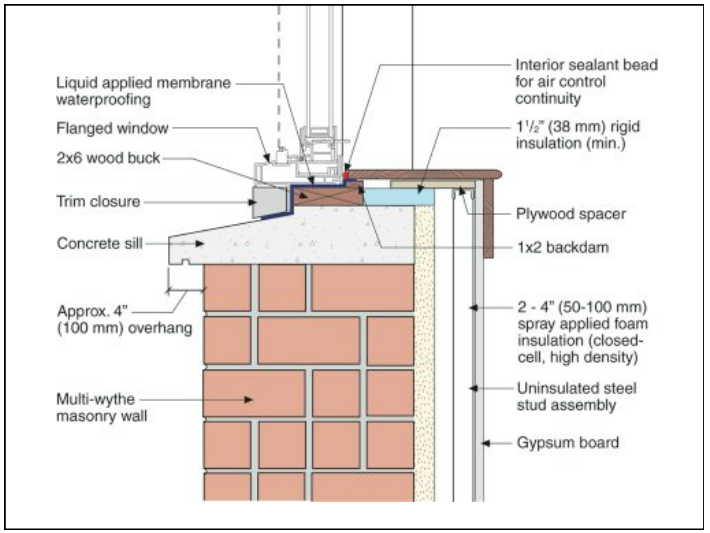
- Beware air leakage at premade sill flashing



- Beware thermal bridge of metal sill pans

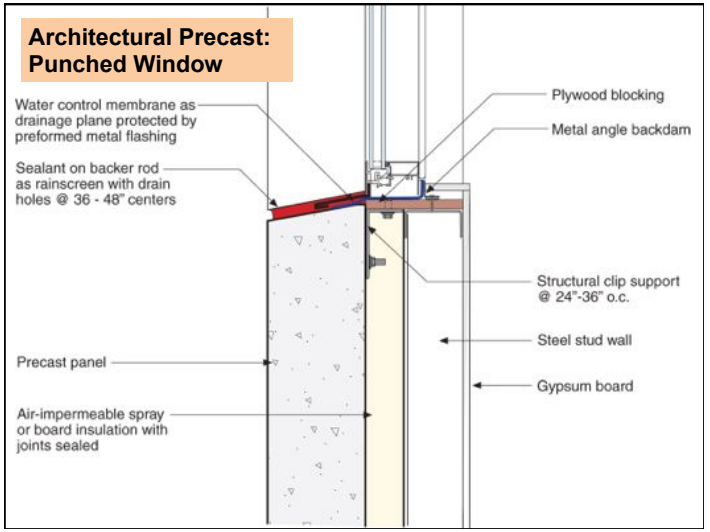
- Face of foam as air/water layer



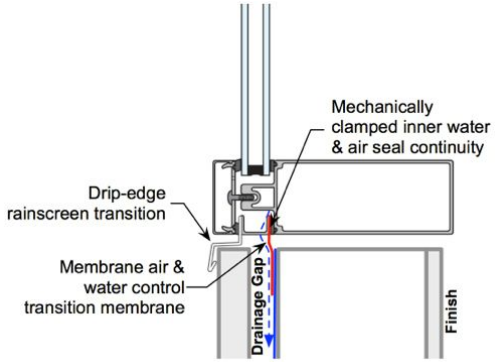


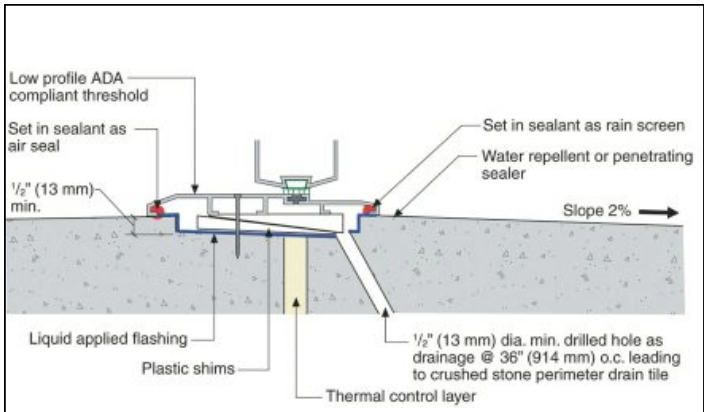
Continuous interior angle provides backdam and airseal continuity

Architectural Precast: Punched Window



Curtainwall Integration





Roof-Wall

- Water control
  - sometimes overhangs, sometimes continuous
- Air control
  - Sometimes roof membrane, sometimes ceiling plane

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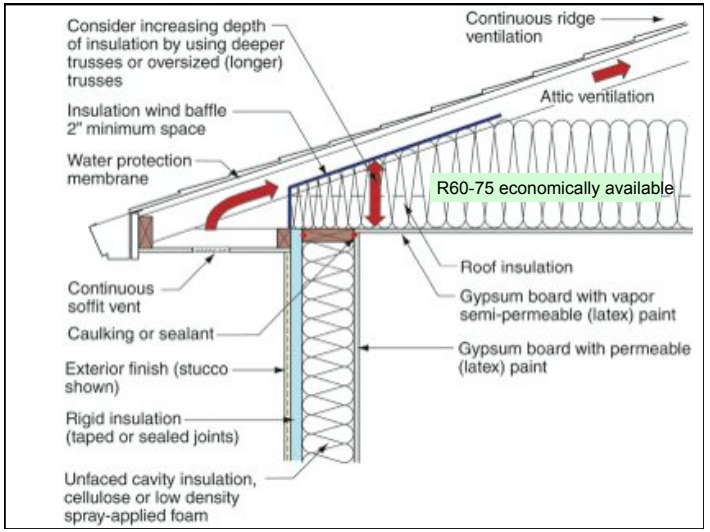
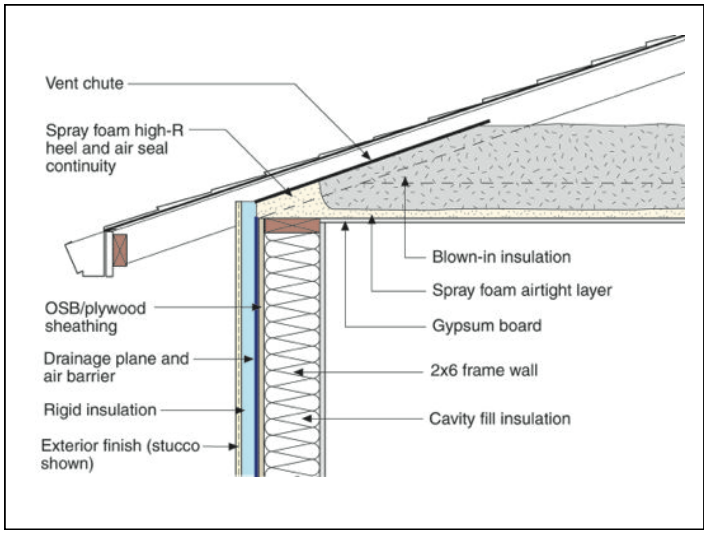
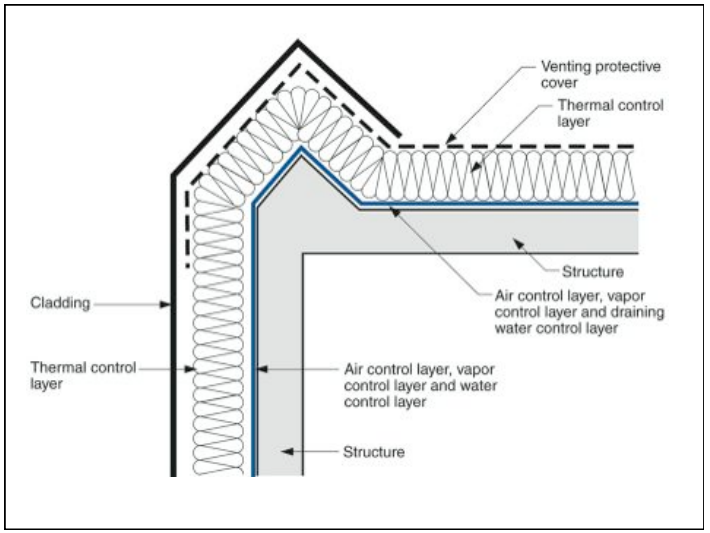
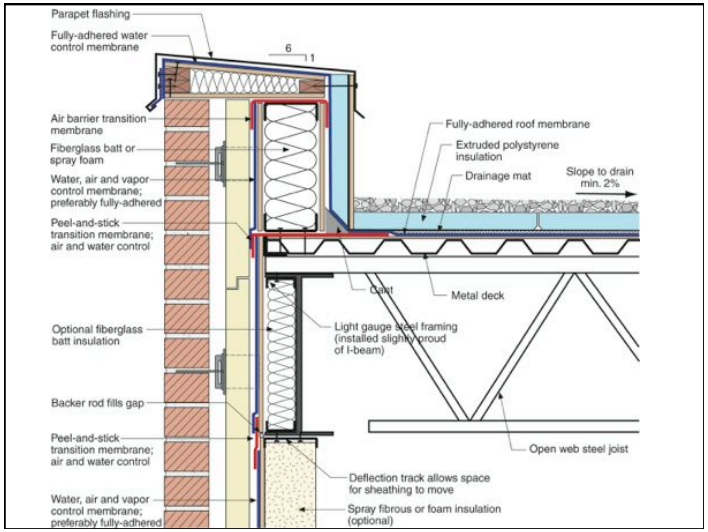
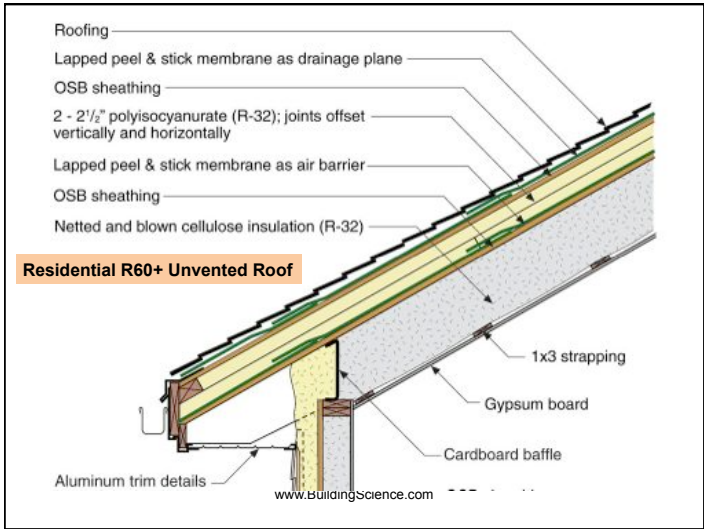



Vent chute
Spray foam high-R heel and air seal continuity
Blown-in insulation
Spray foam airtight layer
OSB/plywood sheathing
Gypsum board
Drainage plane and air barrier
2x6 frame wall
Rigid insulation
Cavity fill insulation
Exterior finish (stucco shown)


Venting protective cover
Thermal control layer
Structure
Cladding
Air control layer, vapor control layer and draining water control layer
Thermal control layer
Air control layer, vapor control layer and water control layer
Structure


Parapet flashing
Fully-adhered water control membrane
6
1
Air barrier transition membrane
Fiberglass batt or spray foam
Water, air and vapor control membrane; preferably fully-adhered
Peel-and-stick transition membrane; air and water control
Fully-adhered roof membrane
Extruded polystyrene insulation
Drainage mat
Slope to drain min. 2%
Cant
Metal deck
Optional fiberglass batt insulation
Light gauge steel framing (installed slightly proud of I-beam)
Backer rod fills gap
Peel-and-stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Water, air and vapor control membrane; preferably fully-adhered
Spray fibrous or foam insulation (optional)


Roofing
Lapped peel & stick membrane as drainage plane
OSB sheathing
2 - 2½" polyisocyanurate (R-32); joints offset vertically and horizontally
Lapped peel & stick membrane as air barrier
OSB sheathing
Netted and blown cellulose insulation (R-32)
Residential R60+ Unvented Roof
1x3 strapping
Gypsum board
Cardboard baffle
Aluminum trim details
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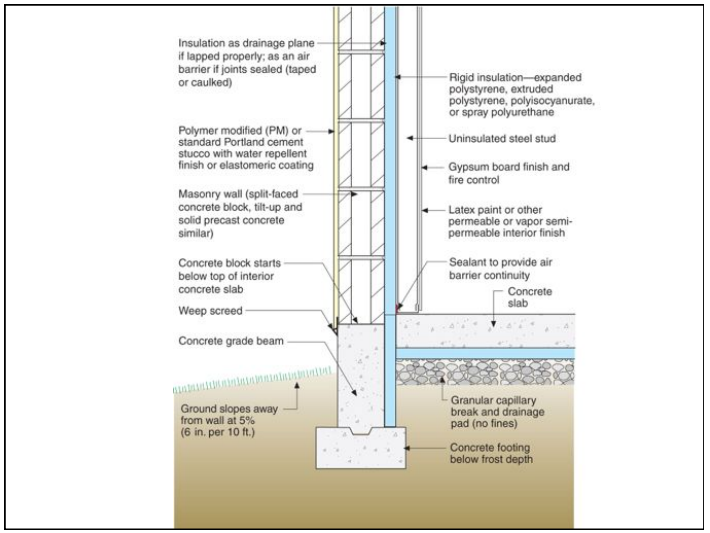
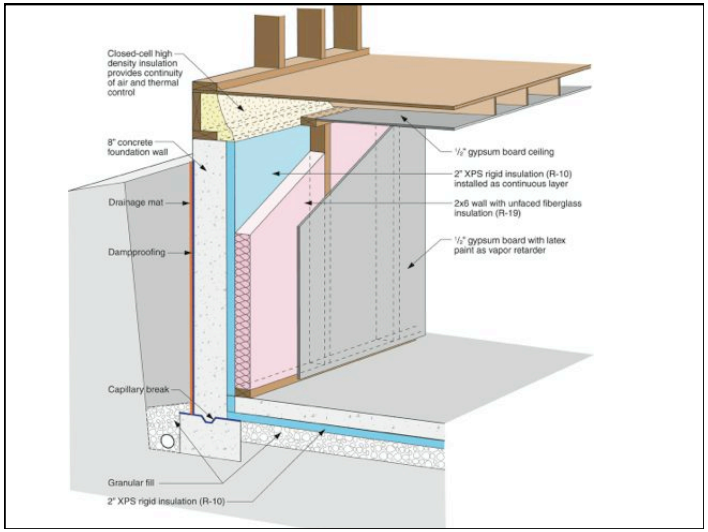
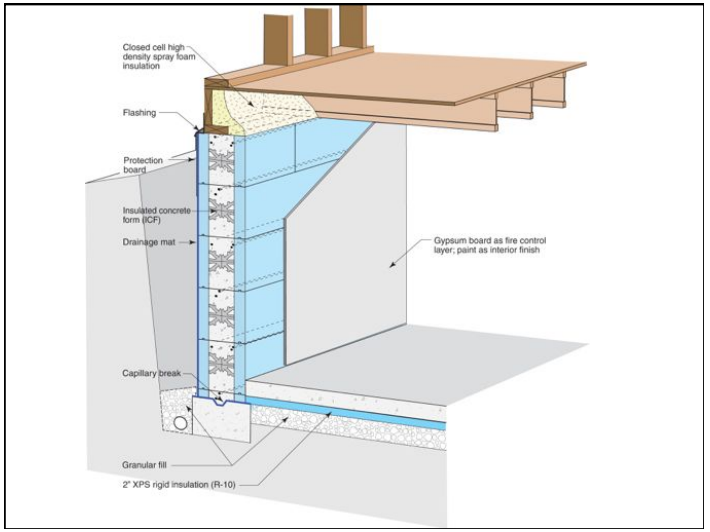
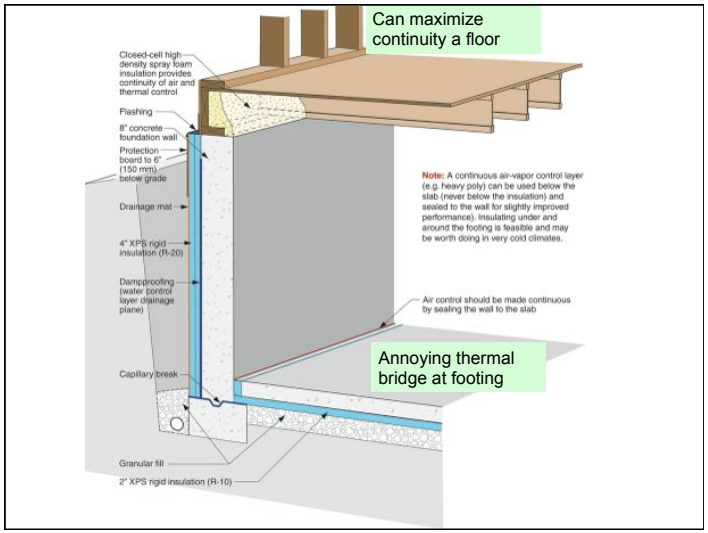
Basement Wall-Slab

- Continuity of air-thermal barrier a challenge at slab
- Continuity at floor slab also!

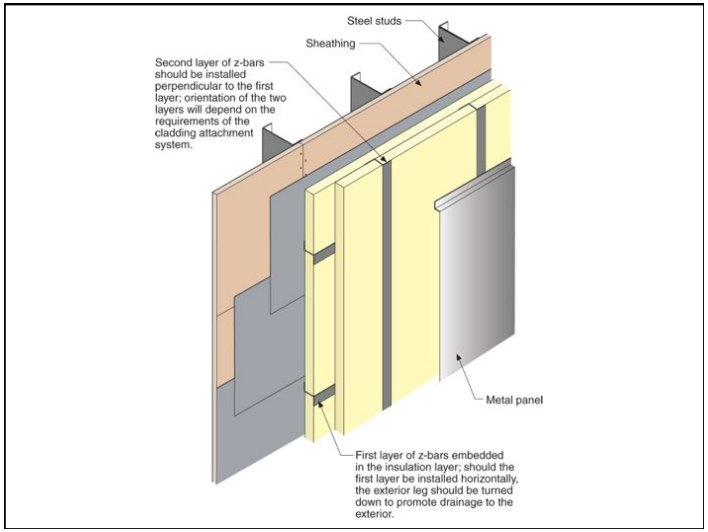


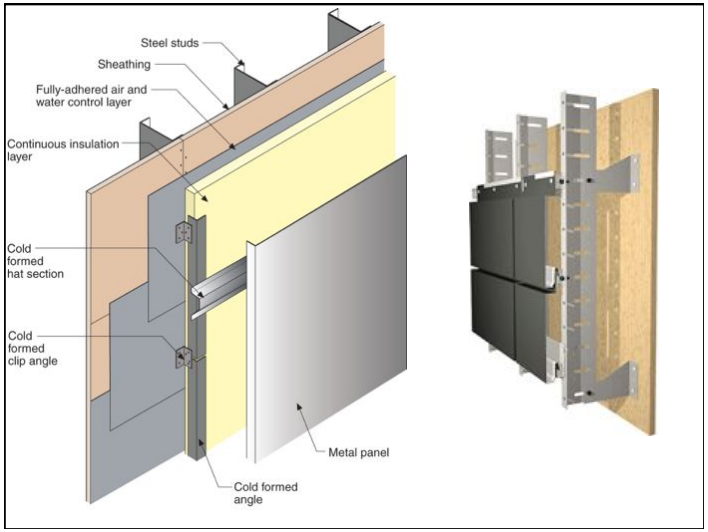


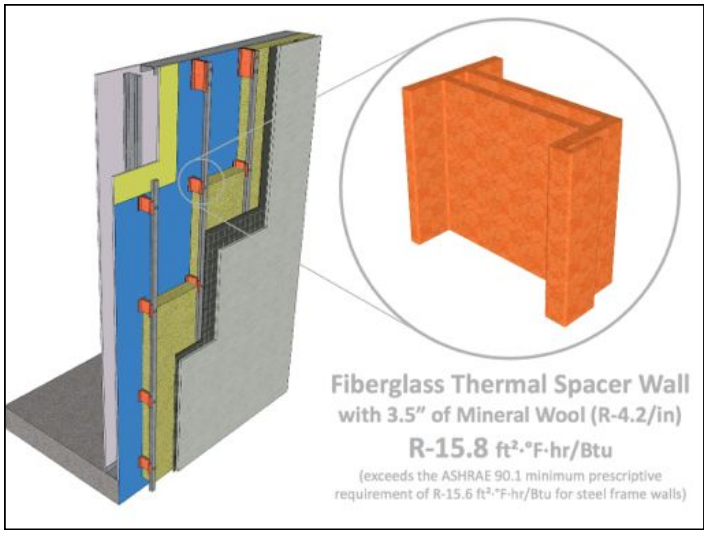


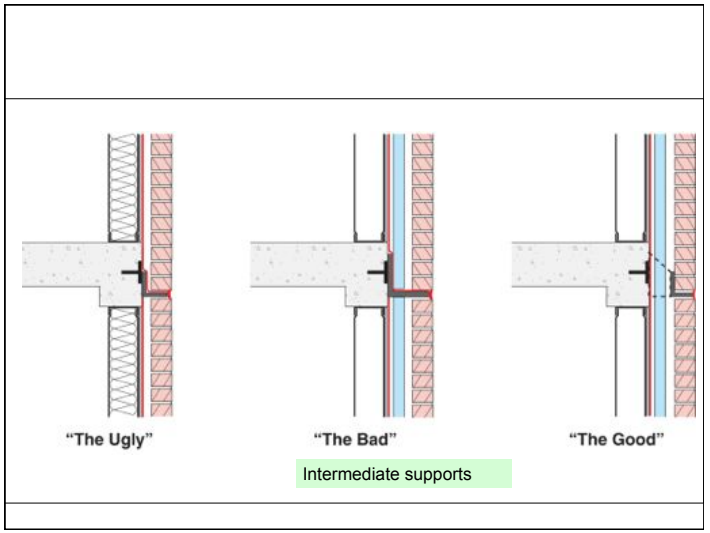

Can maximize continuity a floor
Closed-cell high density spray foam insulation provides continuity of air and thermal control
Flashing
8" concrete foundation wall
Protection board to 6" (150 mm) below grade
Drainage mat
4" XPS rigid insulation (R-20)
Dampproofing (water control layer drainage plane)
Capillary break
Granular fill
2" XPS rigid insulation (R-10)
Note: A continuous air-vapor control layer (e.g. heavy poly) can be used below the slab (never below the insulation) and sealed to the wall for slightly improved performance). Insulating under and around the footing is feasible and may be worth doing in very cold climates.
Air control should be made continuous by sealing the wall to the slab
Annoying thermal bridge at footing

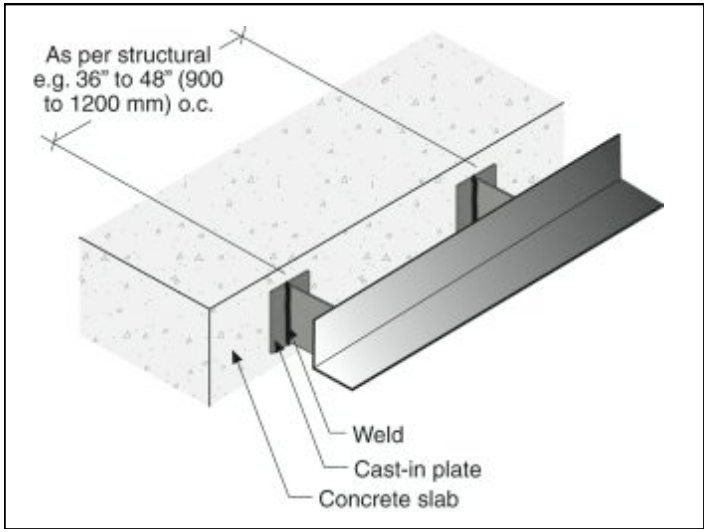
walls

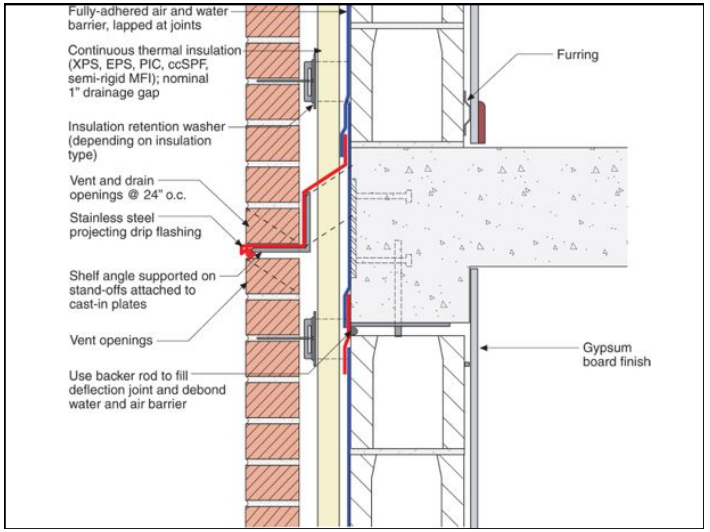

Steel studs
Sheathing
Second layer of z-bars should be installed perpendicular to the first layer; orientation of the two layers will depend on the requirements of the cladding attachment system.
Metal panel
First layer of z-bars embedded in the insulation layer; should the first layer be installed horizontally, the exterior leg should be turned down to promote drainage to the exterior.


Steel studs
Sheathing
Fully-adhered air and water control layer
Continuous insulation layer
Cold formed hat section
Cold formed clip angle
Metal panel
Cold formed angle

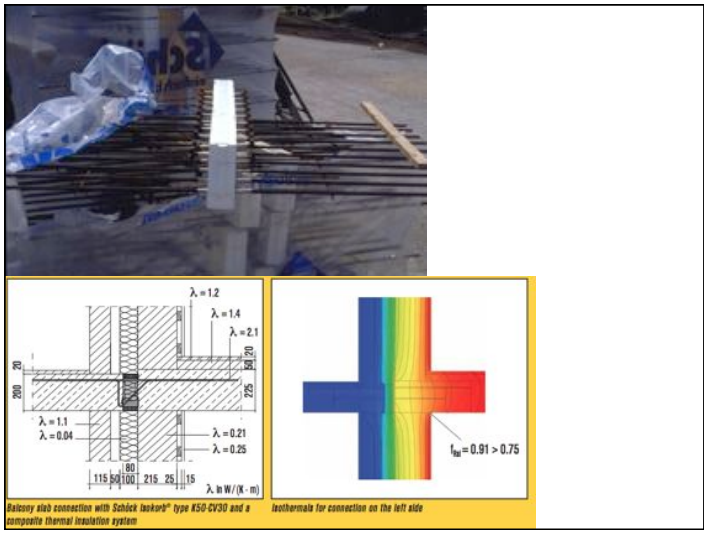

Fiberglass Thermal Spacer Wall
with 3.5" of Mineral Wool (R-4.2/in)
R-15.8 ft²·°F·hr/Btu
(exceeds the ASHRAE 90.1 minimum prescriptive requirement of R-15.6 ft²·°F·hr/Btu for steel frame walls)

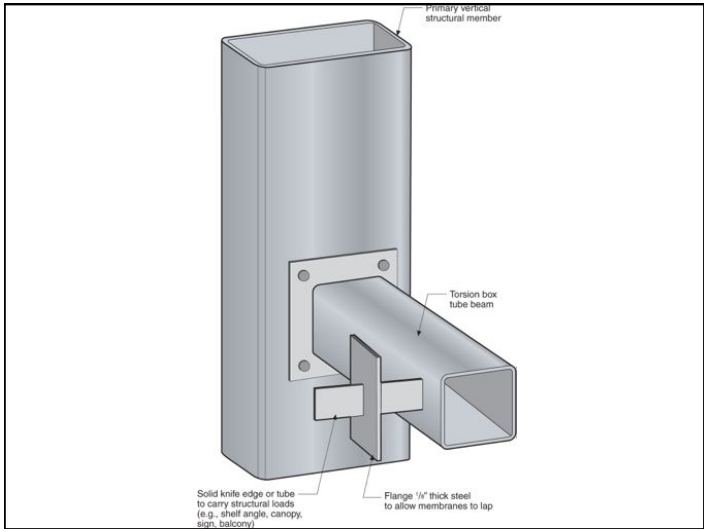

"The Ugly"
"The Bad"
"The Good"
Intermediate supports

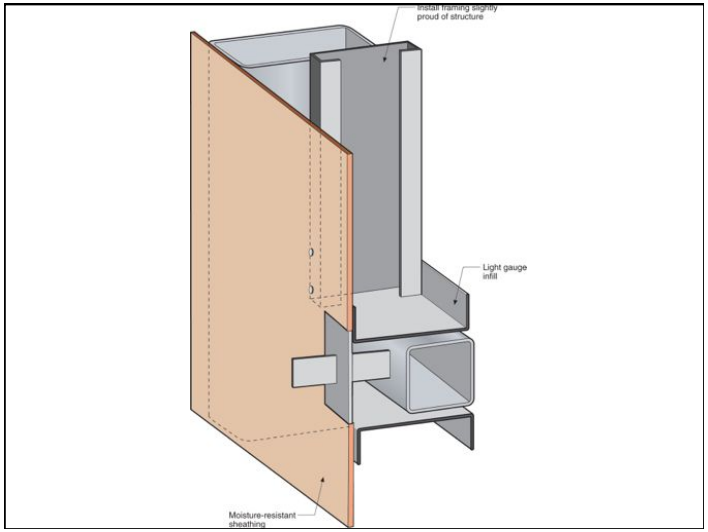

As per structural
e.g. 36" to 48" (900 to 1200 mm) o.c.
Weld
Cast-in plate
Concrete slab

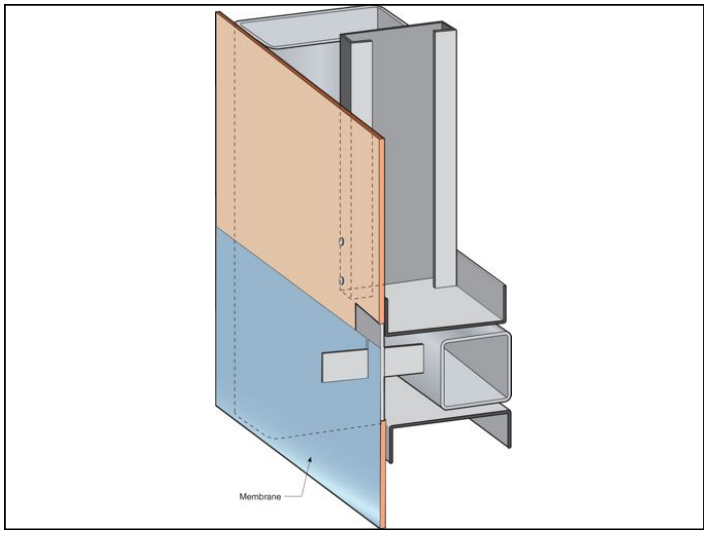

Fully-adhered air and water barrier, lapped at joints
Continuous thermal insulation (XPS, EPS, PIC, ccSPF, semi-rigid MFI); nominal 1" drainage gap
Insulation retention washer (depending on insulation type)
Vent and drain openings @ 24" o.c.
Stainless steel projecting drip flashing
Shelf angle supported on stand-offs attached to cast-in plates
Vent openings
Use backer rod to fill deflection joint and debond water and air barrier
Furring
Gypsum board finish

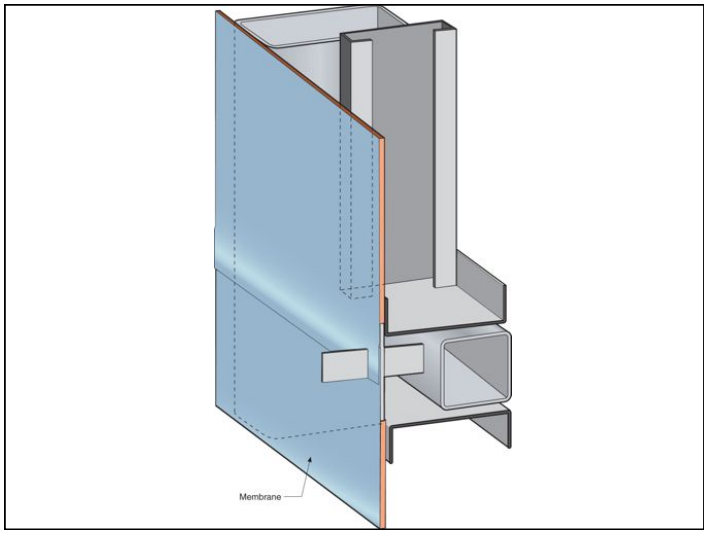

Small metal clips
dramatically reduce
thermal bridging


Balcony slab connection with Schöck Isokorb® type KS0-CV30 and a composite thermal insulation system
Isothermals for connection on the left side


Primary vertical structural member
Torsion box tube beam
Solid knife edge or tube to carry structural loads (e.g., shelf angle, canopy, sign, balcony)
Flange ⅛" thick steel to allow membranes to lap


Install framing slightly proud of structure
Light gauge infill
Moisture-resistant sheathing





Rigid Exterior Air Barrier

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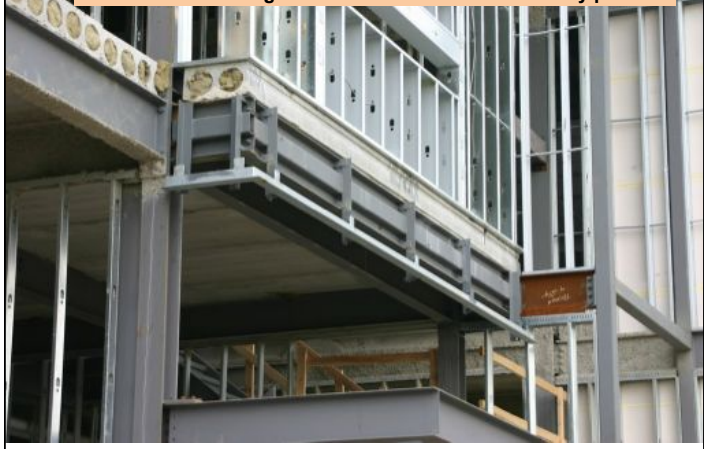
Commercial Buildings: Often exterior air barrier is only practical so



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